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James Bryan Attorney
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James W Bryan

Thomas Bond

Chemistry is that science which investigates the composition of bodies & the changes of constitution which they produce by their actions upon each other." >

"Natural Philosophy investigates the laws of the material world."

"Efflorescence is that tendency which certain bodies have when exposed to the air to fall into white powder."

OUTLINES

OF THE

LECTURES

ON

CHEMISTRY, MINERALOGY, & GEOLOGY,

DELIVERED AT THE

UNIVERSITY OF NORTH-CAROLINA,

For the use of the Students.

RALEIGH:

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1819.

Investigates the comp. of bodies & the changes they produce on each other

ORDER OF THE COURSE.

1. Introductory Lecture.
2. Attraction.
3. Light.
4. Caloric.
5. Galvanism.
6. Atmospheric Air.
7. Water.
8. Alkalies.
9. Earths.
10. Natural History of the Earths. { 1. Mineralogy.* 2. Geology.
11. Acids, including their Bases and combinations with the Alkalies and Earths.
12. Metals.
13. Mineral Waters.
14. Vegetable Chemisty.
15. Animal Chemistry.
16. Agricultural Chemistry.

* Mineralogy of the Inflammables and Ores given in connexion with their Chemical History.

INTRODUCTION.

1. DEFINITION OF CHEMISTRY.

Natural History---" ascertains the different bodies in the universe, and arranges them systematically,"---respects *facts*.

Natural Philosophy--" investigates the changes which bodies produce by their action on each other,"---respects *causes*,---divided into Mechanical Philosophy and Chemistry.

Mechanical Philosophy---" treats of those changes in natural bodies which are accompanied by *sensible* motions."

Chemistry---" treatsof those changes in natural bodies which are *not* accompanied by sensible motions." (*Thomson* 1, 18. *Black* 1, 11.)*—distinction between the objects of the mechanical philosopher and the chemist illustrated by a river of water.

2. HISTORY.

Chemistry existed among the ancients as an *art*—distinction between an art and a science. *Alchemy*—how distinguished from Ch.—traced back to Julius Firmicius Maternus of the 5th century---*three* objects of the alchymists—Alchymy introduced from Arabia into Europe by the Crusaders—Basil Valentine—Paracelsus---rise of Lord Bacon's philosophy—Beecher and Stahl—Phlogistic Theory of Combustion—when overthrown. (*Encyclopædia Britannica---Brand's Third Dissertation.*)

3. APPLICATIONS TO MEDICINE AND THE ARTS.

1. To *Medicine*. Composition of animal substances ascertained—changes produced in substances by their Chemical action on each other—a knowledge of the laws of affinity necessary in the preparation of medicines—analysis of poisons. (*Cooper on Medical Chemistry.*)

2. To the *Arts*. Chemical principles involved in the arts of dyeing, soap-making, cookery, pottery, glass-making and agriculture—artificial mineral waters—steam engines & steam-boats—safety-lamp. (*Henry* 1, 17.—*Parkes* 1.)

4. MOTIVES TO STUDY CHEMISTRY.

1. Explanation of natural phenomena.
2. Moral and intellectual advantages arising from the study of the works of Nature.

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* The references are made for the convenience of the Student, where it may be well to consult some work besides the Text Book.

PART I.

GENERAL PRINCIPLES.

Division of a system of Chemistry into general doctrines and particular bodies—bodies either simple or compound—definition of each—number of simple bodies known. (*Thomson* 1, 25.)—elements of the ancients—general doctrines, so called because their influence extends to all bodies—include Attraction, Light, Caloric, and Galvanism.

DIV. I.—OF ATTRACTION.

Different kinds of Attraction—Gravitation, Magnetism and Electricity assigned to Mechanical Philosophy, because they act on masses, and at sensible distances—that kind which acts on particles, and at insensible distances, assigned to Chemistry.

A mass made up of either homogeneous or heterogeneous particles—examples of each.—*Aggregation*, "that force by which *similar* particles are united in one body."—*Affinity*, "that force by which *different* particles are united in one body."—Constituent parts—integrant parts—examples of each—*Cohesion*, "that force which unites the *integrant* particles into a mass." (*Conversations on Chemistry*, 1, 18.—*Murray's Elements* 1, 32.—*Henry* 1, 59.)

Cohesion strong in *solids*—weak in *fluids*—none in *gases*—why mercury does not adhere to a glass tube?—why water does adhere?—why the surface of mercury is spherical?

Cohesion overcome in two ways—why heat overcomes it—why a liquid overcomes it—process forms solution—a fluid dissolves a solid by overcoming its cohesion—a solid sometimes dissolved by air—by another solid—principle?—Cohesion resumed when the causes of separation are removed—examples—a solid recovered from a solution either in a regular or an irregular form—when regular, *crystallization*. (*Murray* 1, 24.)

Of Chemical Attraction or Affinity.

Def.—difference between combination and mixture—separation of ingredients by filtration—decomposition—Chemical Analysis and Chemical Synthesis defined—importance of this subject to the Chemist. (*Murray* 1, 32.)

LAWS OF CHEMICAL ATTRACTION.

1st Law.—Chemical affinity takes place only between bodies of a different nature.

2d Law.—Chemical affinity takes place only between the minutest particles of bodies.

Combination promoted by rasping, filing, grinding, pulverizing, &c.—why?

3d Law.—Chemical Affinity takes place not merely between two, but also between three, four, or any number of bodies.

Most compounds complicated—animals and vegetables.

4th Law.—Insolubility, high specific gravity, efflorescence, and elasticity, by their tendency to separate bodies, oppose chemical combination and favor decomposition.

Insolubility the effect of cohesion—effect produced by diminishing the quantity of the solvent—by presenting to a substance in solution another body with which it forms an insoluble compound.

How *great specific gravity* opposes the union of two substances—how counteracted.. By agitation

Efflorescence defined—how it opposes combination—influence small. Salts when exposed to the air decompose into a white powder

Elasticity an important agent—what kind of bodies does it influence most?—why an aeriform body combines more readily with a fluid than with another aeriform body—why pressure and cold promote the combination.

5th Law.—When bodies combine together, they undergo a change of density, and a change of temperature.

Change of temp. on increasing the density—heat given out—on diminishing it. (*Murray* 1, 38.)

6th Law.—The compounds formed by chemical affinity, possess new properties, which are different from those of the constituent parts.

Opinion of the old chemists on the intermediate nature of compounds—is the change of properties equally great in all cases?—example of a slight change—of a great change—general rule respecting the extent of the change of properties.

7th Law.—Bodies have different degrees of affinity for each other.

Importance of this law—why important—how a compound of two principles is decomposed by a third—chemical tests—Berthollet's views of the influence of *quantity* on chemical affinity—single elective attraction—double elective attraction—how a compound of two principles is decomposed by another compound of two principles.

8th Law.—The force of chemical affinity is estimated by the force which is necessary to separate the substances which enter into combination.

Method of ascertaining by experiment the relative affinities of several substances for a given body---Bergman's Tables of Affinity.

Proportions in which bodies combine.

1. No limitation—salt with any quantity of water.

Sugar & water. Salt = caustic soda + muriatic acid.

2. Limited on one side—water saturated with salt.
3. Limited to *one* proportion.
4. Two ingredients combine in two, three or four proportions—these proportions *definite*.

DIV. II.—OF LIGHT.

Nature of L.—two theories—that of Descartes, Huygens, and Euler—that of Newton—proofs that it has a distinct existence from heat.

Chemical Effects.

Light is capable of entering into bodies, and of being afterwards extricated without alteration. Examples—fish hung up to dry—meat in a putrescent state—loaf sugar and pieces of marble struck together in the dark—snow—rotten wood—the diamond.

Light combines with various bodies & changes their properties.

1. With *Vegetables.* How their properties are altered by growing in the dark—tendency of such plants towards the light—changes in the properties of vegetables produced by light, e. g. cabbage, celery, potatoes—Prof. Robinson's expt.—will the light of a lamp produce the same change as that of the sun? (*Black* 1, 372.)

2. With *Animals*—phosphorescence of ignes-fatui—the glow-worm—luminous appearance of the sea—chiefly affects the surface—variety of complexion of the human species—effect in bleaching certain substances. (*Encyclopædia Brit. Art. "Light."*)

DIV. III.—OF CALORIC.

Distinction between the terms heat and caloric.

1. *Nature of Caloric.*

Two theories—1. That the heat of any substance is produced by a vibratory motion of its particles—2. That heat is a substance *sui generis*—supposition that heat is the same with light—Herschell's expts. on the different sorts of rays emitted by the sun—three sorts—their names. (*Thomson* 1, 31.—*Conversations on Ch.* 1, 32.)

2. *Effects of Caloric.—Expansion.*

H. expands all bodies—comparative degree of expansibility of solids, fluids and gases—air eight times as much as water—water 45 times as much as iron. (*Thomson* 1, 68)—fluids more expanded by equal additions of heat as they approach the boiling point—why?—not so with gases---why?

Practical application of the property of Expansion.

Tyring of wheels--gridiron pendulum, *(Black*, 1, 8.*)* phenomena explained --cracking of glass by sudden heating or cooling---method of cracking glass for use.

THERMOMETER.

Def. " a measure of heat"- general description and principle---history---air therm. of Sanctorio--why quicksilver is best adapted for the thermometrical fluid---two fixed points agreed on---Fahrenheit's therm. --how graduated---why it begins at 32° below the freezing point of water---what constitutes the principal difference between thermometers ?-- Celsius's used in Sweden- -how graduated---Reaumeur's- -Spirit of Wine ther. used to measure great degrees of cold- -why ?

Wedgewood's Pyrometer--construction--graduation--at what degree of Fah. it begins---how many degrees of Fah. one deg. equals *(Cavallo)* Points to be remembered.

1. Freezing and boiling pts. of Water.
2. do. do. of Mercury.
3. Medium temp. of the globe.
4. Temp. of the human body.
5. Greatest heat yet measured.
6. Greatest cold do. *(Henry* 2, 354.*)*

Remarkable exception to the law of expansion in the case of water—beneficial consequences of this—phenomena depending on this property of water---heaving of pavements---bursting of cannon - expansive force of freezing water 27720 lbs.---cause---a few metals subject to the same exception. *(Black* 1, 40.*)*

3. *Radiation of Caloric.*

Repulsive property of C. --constant tendency to an equilibrium---division of C. among different substances laid side by side at different temperatures---C. distributed in two ways.

Radiation " the emission of heat in right lines from the surfaces of bodies."

Reflection—laws of reflected heat the same as those of light—bright metallic surfaces—why vessels of this kind are difficult to heat—why they are suitable for imprisoning heat—metallic tea-pots—Pictet's expts. with metallic mirrors—effect produced by placing a mass of *ice* in one focus—*Leslie's* expts.—radiating power of different coloured surfaces—two tin kettles, one blackened—tin canister with different coloured sides—*differential thermometer*—object—construction—how is it sensible to any change of temp. in the focus, but not to any change in the temp. of the room ?—what surfaces absorb heat

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best—Dr. Franklin's expt. with different coloured cloths—Leslie's expts. on this subject, by coating the focal ball-- surfaces which *radiate* best, absorb best --surfaces which *reflect* best, absorb worst. (*Henry* 1, 90. *Murray* 1, 151. *Conversations* 1, 43.)

Practical Applications---tin roasters -- FIRE PLACES --should the sides be perpendicular or oblique to the back ?- -smooth or rough ?-- advantages of constructing fire places small---size of the draught---what vessels are most suitable for *confining* heat ? ---for *diffusing* it ?

APPAREL---two objects, to screen us from the external heat, or to preserve the internal---1. In *Summer* light coloured clothing best in the sun---dark coloured in the shade—why negroes bear the heat better than white people. 2. In *Winter*—principal object to *confine* the heat of the body—what colours best adapted to this purpose---why negroes do not bear the cold so well as white people.

4. *Conducting Powers of Bodies.*

When heat is said to be *radiated*-- when *conducted*—what is meant by good conductors ?---by *bad ?*- what class of bodies are the best conductors—Dr. Ingenhouz's expt. with a box and diff. metallic cylinders coated with wax (*Henry* 1, 93)—conducting powers of the metals --

1. Silver.
2. Gold.
3. Copper and Tin (nearly equal)
4. Platina, Iron, Steel, Lead, (much inferior to the others.)

5. Is the conducting power proportioned to the density ?-- two properties essential to vessels for heating fluids---two ditto for diffusing heat --why iron stoves are so effectual in heating apartments---cooking stoves---*stones*, *brick*,---which make the warmest houses ? which most suitable to apply to the feet of the sick -- use of bricks in furnaces---*Glass*---*Dry Wood*---*Charcoal*---used in lining furnaces---*Plumbago*--- use for crucibles---*Straw*---straw hats---use for ice houses---in protecting garden vegetables from the frost--conducting power of light substances, wool, hair, &c.---polar animals --why clothes keep us warm --snow.

Fluids---carrying power---how is heat propagated in fluids---are fluids absolute non-conductors---to what part of the vessel should heat be applied---broad stills.

AIR---What takes place when a *hot* body is exposed to the air---when a *cold* body ?-- conducting power of confined air---double tin vessel---why winds and breezes feel cool.

Sensations of heat and cold---supposition of "particles of cold"---real cause of the sensations—experiment--why some substances *feel* colder than others at the same temp.---should a linen or a woollen cloth be wrapped round a cake of ice?--painful sensation on touching frozen mercury.

5. *Theories respecting the Distribution of Caloric.*

1. *Pictet's* --repulsive power of the particles o . when accumulated.

2. *Prevost's*---exchange of C. between all contiguous bodies. (*Thomson* 1, 65.)

Does C. produce heat on a *transparent* medium? effect when a combustible substance is interposed—how heat is preserved on the surface of the earth—why it does not rise to the top of the atmosphere—term of congelation—figure described by all these points taken together—why heat does not accumulate on high mountains.

5. *Cold.*

Argument against considering cold a mere *negative* principle--common explanation of this difficulty. (*Thomson* 1, 114--*Henry* 1, 91) —reasoning disapproved. (*Murray* 1, 144—*Annals of Philosophy* 7, 223.)—Terrible effects of cold in northern latitudes—*artificial* cold—lowest degree yet produced—freezing mixtures—method of producing the most intense cold.

6. *Fluidity.*

How may every solid become fluid—every fluid solid—example in the case of water—melting point defined—uniform in the same body—different in different bodies.

What are the melting points of

1. Ice, 3 Tallow, 5. Tin, 6. Copper,
2. Olive Oil, 4. Beeswax, 6. Lead, 7. Iron.

Quicksilver not admitted among the metals by Boerhaave—why?

Investigations of Dr Black to discover the cause of fluidity—erroneous ideas formerly entertained respecting the liquefaction of ice—a remarkable circumstance attending the liquefaction of ice—Experiments (*Black* 1, 115.) (1st.) a pound of water at 33° and a pound of ice at 32°—exposed to equal

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additions of heat in a warm room—water rose to 40° in half an hour—ice rose to 40° in twenty one half hours—heat entered both at the rate of 7° every half hour—Therefore, 21 × 7 = 147 entered the ice to raise it 8°—Hence 147 − 8 = 139 must have combined with the ice to turn it into water—2d. a pound of water at 172 mixed with a pound of ice at 32—resulting temp. ?

LATENT HEAT defined—"that quantity of caloric which bodies absorb in changing their form"—applied to fluids—that quantity of c. which combines with the solid out of which the fluid is formed, constituting its fluidity, but does not raise its temperature.

Different in different bodies—what is meant by saying the latent heat of tin is 500?—distinguished from the melting point.

PRACTICAL APPLICATIONS.—Chilling winds while snow is melting—water remaining fluid below 32—why?—explanation of freezing mixtures—heat given out by congelation.

7. *Vapour.*

Æriform bodies—distinction between a vapour and a gas—vapour invisible—not mist—process of ebullition—reason of the agitation—boiling point defined—boiling points of

1. Ether, 96 3 Water, 212
2. Alcohol, 176 4. Mercury. 672

Influence of atmospheric pressure on the boiling point, illustrations of this pressure—discovered by Galileo—Torricellean vacuum how formed—principle of the barometer—at what point will water boil in vacuo—evils that would result were this pressure removed—why ether boils under the receiver of an air-pump—Effects produced on the human system by diminishing the atmospheric pressure—in ascending mountains—firing heavy artillery—Thermometer for measuring heights—Effect produced on the boiling point by increasing the pressure—Papin's Digester—boiling water can be raised only to 212—why? erroneous ideas formerly entertained on this subject—consequences that would follow were these ideas correct—how Dr. Black ascertained the latent heat of steam, (*Black* 1, 164)—latent heat of steam 940° why vapour produces cold—why dry wood is better for fuel than green.

SOLVENT POWER OF STEAM—dissolves horns, hoofs, &c.—steam washing machines—Steam Kitchens—heating apartments by steam.

EXPANSIVE POWER OF STEAM. Illustrated by the eolipile—Digester—candle bombs—effect of moisture on casting moulds—accidents produced by spitting in a caldron of melted copper.

Steam Engine.---Inventor---who *constructed* the first engine (*Encyclopædia Brit. American Journal of Science* 1, 157) ---principle of *Savary's* Engine---a vacuum formed in the receiver by the condensation of steam---water rises into the receiver about 25 feet by the pressure of the atmosphere---forced up the remainder of the way by the pressure of steam let in from the boiler---*defects*---waste of fuel -danger of explosion---cannot raise water more than 100 feet--*Newcomen's*--water raised by a lever—this raised and depressed by the piston—a vacuum formed below the piston and the *atmosphere* forces it down—steam admitted below, balances the atmospheric pressure, and the piston is *dragged* up by the preponderancy of the other arm of the lever—great defect of Newcomen's engine, the expense of fuel—120,000 bushels coal a year—¾ of the steam wasted, chiefly by admitting cold water into the cylinder to condense the steam.—*Watt's*—two peculiarities—(1) steam condensed in a separate vessel—(2) piston forced down by *steam*—Savary's, Newcomen's and Watt's Engines compared in *principle*—(1) Water raised 25 feet by atmospheric pressure, then forced up 60 or 70 feet farther by steam. (2) Piston *forced down* by atmospheric pressure, and *dragged up* by the preponderancy of the opposite arm of the lever.

Terms on which Watt and Bolton erect engines—force of an engine how estimated—distinction between high and low steam—which species of boiler most advantageous—why? *safety* the principle question—arguments for each compared. (*Rees' Cyclopædia Art.* "*Steam Engine.*")

Steam Frigates—intended for the defence of the coast, harbours, &c.—advantages over ships of war.

Steam Mills—particularly useful where water courses are wanting.

Steam Packets on the Mediterranean.

8. *Natural Evaporation.*

Vapour formed at all temps.—distinction between the terms evaporation and vaporisation—evap. takes place at the surface—form of vessels—effect of agitation—elasticity decreases with the temp.---oil of vitriol and fixed oil exceptions.

Evap. produces cold---why?---why wet clothes hung out to dry are frozen when the air is above 32---why it is unhealthy to sit in wet clothes---why sprinkling the floor cools the room ---porous vessels---wine coolers - manufacture of ice at Benares---circumstances which contribute to heighten the effect---how travellers on the desert keep water cool. (*Black* 1, 202)

Artificial

effects of perspiration---why dangerous to expose oneself to a current of air when in a state of perspiration--high heat which the human system can sustain-- Expts. of Dr. Fordyce and others. (*Encyc. Brit. Art*, "*Heat---Phil. Transactions Vol. 15th.*)

Effects of evap. on the economy of Nature-- Dr. Watson's expt.- great quantity of water thus raised into the atmosphere- -what becomes of it ?--clouds, rain-- solution theory--- terms defined, solution, solvent, saturation, precipitation---dew, frost and snow-- why moisture collects on a cup of cold water-- on the windows---smoke from a hole in the ice---beneficial effects of moisture on the atmosphere---evils of too much moisture.

9. *Quantity of Caloric in Bodies.*

C. appears in two states- -what is meant by *free* C.---what by *combined* ?---bodies contain heat not sensible to the thermr.---ice contains it --difficult to determine the point of *absolute cold* --attempts of Dr. Irvine and others---results various---not entitled to credit-- *comparative* quantity of C. more easily ascertained --a pound of water and a pound of mercury placed side by side in a hot oven---how much more *sensible heat* would the mercury acquire than the water in a given time.

Specific Caloric-- "that quantity of caloric which a body has compared with another of the same weight"—or "that quantity of caloric which a body requires to raise its temp. any number of degrees, compared with another body of the same weight"—how both definitions amount to the same thing —distinction between specific and latent Caloric- modes of investigating the specific C.-- (1) that of Crawford by mixing bodies at different temps.---Examples.

1. Water at 100° with Water at 50° } resulting temp.

2 Water at 156° Mercury at 40° } resulting temp.

(2) That of Lavoisier and La Place by means of the *Calorimeter*---principle and construction of this instrument.

Capacity of bodies for Caloric---the power of stowing away heat so as to render it insensible to the ther.---*increase of capacity produces cold*---most perceptible in aeriform bodies --fountain of Hicro in Hungary---(*Aikin's Dic.* 1, 213)-- *diminution of capacity produces heat*---condensing syringe.

10. *Sources of Calo ic.*

1 The Sun,	3. Percussion,	5 Chemical Action.
2. Condensation,	4. Friction,	6. Electricity.

Sun---range of natural heat not more than about 160° --maximum of summer heat higher in northern than in southern latitudes--causes that prevent the accumulation of the solar heat--how high a spot may be heated by the sun's Rays when protected from a current of air. (*Murray* 1, 18?)---small range of heat the human system can bear without artificial aid --about 10 degrees---these at a higher standard in hot than in cold climates --great heat produced by concentrating the sun's rays.

Condensation --hammering iron--sulphuric acid and water - condensing syringe.

Percussion-- collision of a flint and ste l-- coining money --heat produced proportioned to the condensation---heat owing to this cause. (*Thomson* 1, 135.)

Friction --Savages kindle fires by rubbing pieces of dry wood together --forests set on fire by the friction of dry limbs- -axles of water wheels---how accounted for---cause obscure- -Murray's theory. (*Murray* 1, 183.)

Chemical Action---an extensive source---includes combustion---fermentation---change of temp. a common phenomenon of mixture.

Electricity---capable of producing the most intense heat.

General reflections on the subject of heat.

DIV. IV.—OF GALVANISM.

Important discoveries made by men of observation from trifling incidents—Galvani—incident that led to his discovery—time when made—first experiments on frogs—supposed the electricity inherent in the animal, and the discharge to be effected by making a communication between a muscle and a nerve—hypothesis otherthrown by Volta—general principle of Volta, *that electricity is excited by the contact of two metals and becomes sensible when they are separated* (*Singer's Electro-Chemistry*, 306.) Some metals more excited by contact than others—silver and zinc or copper and zinc good combinations—all the substances employed in Galvanic expts conductors—*perfect*, metals, charcoal, plumbago—*imperfect*, fluids of different conducting powers (*Cavallo* 2, 246)—These substances combined form a *simple Galvanic circle*.

1st *order*—two perfect conductors and one imperfect—e. g. a piece of silver and a piece of zinc in the mouth.

2d *or er*—two fluids of different kinds with a metal interposed—example, ale drunk from a pewter cup.

Phenomena explained on Galvanic principles—why iron bolts are unsuitable for the copper sheathing of ships—inscriptions on pure lead more durable than those on mixed metals—soldered seams corrode—a piece of zinc in water corrodes faster when in contact with iron (*Cavallo* 2, 245, *Singer* 308.)—Galvanic action on the pivots of time-pieces (*Annals of Philosophy* 7, 161.)

Voltaic Apparatus.

Object to accumulate the electricity and render its effects more striking.

1. *Voltaic Pile*---construction---how discharged.

2. *Couronne des tasses*---a chain of cups or wine glasses, each containing a piece of silver and a piece of zinc, the silver in one glass connected to the zinc in the other by a metallic wire ---how discharged.

3. *Voltaic Battery*---of different forms for different purposes ---boxes with soldered plates the most convenient of any single form—copper and zinc—how arranged—how connected—how discharged—what fluid is interposed between the plates—ends of the battery in different states—zinc positive, copper negative.

Three different objects—1. Combustion or deflagration—2. Effects on the animal system—3. Decompositions—power of producing combustion or deflagration depends on the *size* of the plates—of producing shocks, and decompositions, on the *number*. (*Davy's Elements* 83. *Murray* 1, 237.)

Great Batteries of England—of the Royal Institution 200 boxes, 2000 prs. of plates—astonishing effects (*Davy* 85)—Children's battery of great plates—deflagrating effects (*Ib* 84.)

1. Experiments on the *combustion* of charcoal, metals, &c.—2. Effects on the *animal system*—mode of exhibiting them—why necessary to moisten the skin—powerful effects produced by Aldini on dead animals (*Singer* 335)—on the body of a culprit by Dr. Ure.

4. *Chemical agencies* of Galvanic Electricity.

Decomposition of water—elements evolved at a distance from each other—general law discovered by Hisinger and Berzelius that, when compounds are exposed to the action of the galvanic influence, *combustibles, alkalies and earths pass to the negative pole—oxygen and those substances in which it predominates, to the positive*—forces operate at a great distance—decomposition of salts, earth and oxids—minute quantities detected—decompositions complete—theory of the decomposition of bodies by Galvanism.

Proofs that Galvanism is identical with Electricity (*Murray* 1, 239. *Conversations* 1, 134.)

James W. Sawyer

Theories of the excitement and accumulation of electricity by the Voltaic apparatus.

1. Explanation on *electrical* principles—how excited—how accumulated. (*Murray* 1, 241. *Henry* 1, 169. *Annals of Philosophy*, 3, 32 & 85. *Conversations* 1, 127.)

2. Explanation on *Chemical* principles. 3. Hare's new theory. Difficulties attending both theories.

Geological phenomena resulting from the agencies of Galvanism.

PART II.

CHEMICAL PROPERTIES AND RELATIONS OF INDIVIDUAL SUBSTANCES.

DIV. I.—OF ATMOSPHERIC AIR.

Objects peculiar to mechanical philosophy—to Ch.—(*Cavallo* 1, 282.)—simple or compound?—composed of two gases.

Gases—term borrowed from the Germans—"solid particles in a state of very minute division united with caloric"—base of a gas—distinction between the terms oxygen and oxygen gas—has the base of a gas ever been obtained separate?—when does a gas become *fixed*?—Pneumatic Chemistry—method of weighing and managing the gases—apparatus (*Henry* 1, 115.) no

1. *Oxygen Gas.*

Etymology of the term—how obtained from manganese—degree of heat required—only a portion of the oxygen separated from the manganese by heat—why?—how obtained from nitre—degree of heat—precautions—how obtained from manganese by the aid of sulphuric acid—rationale.

Properties.—1. In supporting combustion—experiments.

2. That principle of atmospheric air which supports animal life.—Can animals exist in any kind of air that does not contain oxygen?—effect on small animals contained in a jar—in which will they live longest, in a jar of oxy. or of common air?—consequences were the atmosphere entirely composed of it—medicinal applications—mode of breathing the gases.

3. Strong tendency to the positive pole of the Galvanic battery—impresses this property on numerous compounds—hence their decomposition.

mean height of the atmosphere. weight &c.

that part which enters into combination with bodies.

2. *Nitrogen or Azote.*

Origin of the names—how formed—can it be withdrawn from the oxygen?—heavier or lighter than air? lighter

PROPERTIES.—On flame—on animals—why a necessary constituent of the atmospere.

3. *Composition of Atmospheric Air.*

One of the elements of the ancients—oxygen first discovered by Priestly, Aug. 1, 1774—called by him *dephlogisticated* air—by Lavoisier, *vital* air -by Scheele *empyreal* air- reason of these several names (*Brand's Third Dissertation* 85—*Aikin's Dic.* 1, 121)—Complete analysis and synthesis first performed by Scheele (*Murray* 1. 256)—supposition that the air was salubrious in proportion to the quantity of oxygen—Eudiometry —"science of determining the proportion of oxygen in a given quantity of air"—result of numerous observations on the composition of air—proportion of the constituents.

Are the elements in a state of chemical combination or mechanical mixture—can a lighter gas ascend in a heavier?

Specific gravity of air—weight of 100 cubic inches.

4. *Theories of Combustion.*

Distinction between comb. and ignition—extensive agencies of combustion—

Theory of PHLOGISTON. Beecher—Stahl—etymology of the name—principles of the theory—separation of phlogiston—heat and light how accounted for—products called calces—how the calx of lead differs from pure lead—how the pure lead is revived from the calx—rationale. (*Thomson* 1, 123. *Brand's Diss.* 35)—general reception of this theory. Objections to it—its existence incapable of proof—substances gain weight by combustion—overthrown by the discovery of oxygen—maintained by Dr. Priestly to the last.

Theory of LAVOISIER. Brought forward in 1775—L. proved that oxygen is absorbed in the calcination of metals—that the increase of weight is exactly equal to the quantity absorbed—that this can be recovered from the calx and so combined with nitrogen as to form common air—2d proof by burning wire in oxygen gas—oxygen disappeared which was found combined with the iron—similar results with sulphur and phosphorus—light and heat how accounted for (*Lavoisier's Elements* 64. *Murray* 1, 271. *Thomson* 1, 121.)

DIV. II.—OF WATER.

Extent to which W. is diffused—one of the elements of the ancients—now known to be a compound.

1. *Composition of Water.*

Analysis by passing steam through a red-hot gun barrel—change in the iron turnings or wire---production of an inflammable gas--rationale of the decomposition. (*Lavoisier's Elements*, 111.)

Analysis by Galvanism. (*Henry* 1, 101.)

Proof of the composition of Water by synthesis--union of the elements how effected--first executed by Cavendish (*Aikin's Dic.* 2, 472. *Thomson* 2, 23)—supposition that the water produced was held suspended by the gases how disproved—product on burning hydrogen in oxygen—the oxygen and hydrogen both *wholly* disappear—a loss of only 4 grs. in 7249 1-3 grs. (*Black* 2, 372. *Parkes* 457)

2. *Hydrogen.*

How made from iron filings and sulphuric acid—rationale—a case of *predisposing* affinity, (*Murray* 1, 53. *American Journal of Science* 1, 434.)

Properties.--1. *Combustibility*—a combustible distinguished from a supporter of combustion--can hyd. burn without the presence of oxygen?

2. *Levity*—lightest of all ponderable substances--how much lighter than air--100 cubic inches weigh 2¼ grs.--application of this principle to the construction of Balloons. Principle on which a balloon ascends—History of balloons (*Hutton's Math. & Phil. Dic.*) Montgolfiers balloons, how constructed ærostation--Rosier--superiority of hydrogen over common air—method of regulating the ascent and descent—uses of balloons.

3. *Detonation with common air*—rationale of the explosion of the air pistol.

4. *Detonation with Oxygen*—explosion by the electric spark—result—explosion by pressure (*Henry* 1, 140)

5. *Effects on animals by respiration*—when pure—mixed with common air—accident of Rosier.

6. *Musical tones*—common explanation—disapproved.

Water thrown on a building in flames supposed to promote combustion—effect of a jet of steam thrown on a jet of flame issuing from a small orifice, or on the flame of a candle, or lamp (*Amer. Journal Science Nos.* 1 & 4.)

3. *Compound Blow-Pipe.*

Invented by Dr. Hare—construction—effects—difference in bodies with regard to fusibility—can any substance resist the action of this instrument—can the heat produced be estimated in degrees of the scale—cause of the production of such intense heat—invention not accidental but arose from philosophical reflection—danger of explosion how obviated—feeble flame produced by burning hydrogen in oxygen made an objection to Lavoisier's Theory of Combustion—reasoning disapproved (*Thompson* 1, 30)

4. *Chemical Properties of Water.*

Absorption of gases by W—in its natural state always contains air—expelled by boiling—insipidity of water that has been boiled—snow-water—how different from common water—unfit for drinking—destruction to fish—why?—quantity of gas absorbed increased by pressure and cold—W. takes up the same volume of condensed gas as of gas under ordinary pressure (*Murray* 1, 298.)

Relation of water to Acids.

Different *states* of water—peculiarities of spring water, well water, rain water and snow water.

Distillation. A method of obtaining water pure—salt water of the sea rendered fresh—experiment performed by order of the King of France on the salubrity of distilled sea water (*Amer. Journal of Science* 1, 172.)

Uses of water—as a beverage—as a solvent—on vegetation—in regulating the temperature of the globe—in promoting the means of commercial intercourse.

DIV. III.—OF ALKALIES.

Signification of the term—number of the alkalies—simple or compound?—nature of their composition—by whom discovered.

Properties. Taste—effect, when caustic, on the *skin*—meaning of the term *caustic*—effect on vegetable blue colours—on yellow colours—these colours used as *tests* for alkalies—what blue liquor most convenient—what yellow—test papers—effect on the caustic alkalies on oils.

1. *Ammonia.*

Called the volatile alkali and hartshorn—why?—why called ammonia—in the state of a gas—how made from Muriate of Ammon. and Quicklime—rationale.

Properties. Smell—suffocating when pure—pleasant when mixed with air—effect on flame—on the colour of the flame of a candle—on the vegetable test colours—how much lighter than air—affinity for water—liquid ammonia how prepared.

Decomposition by the electric spark (*Henry* 1, 186)—by passing ammon. through a red-hot porcelain tube—by exploding by means of the electric spark—by heating with metallic oxids—rationale of the last decomposition—reasons from analogy to suppose ammonia to be a metallic oxide—nature of the proof that it is so.

Ammonia spontaneously produced from decaying animal substances—test for ammon.

Uses—in medicine—in dying—in a variety of chemical operations—effect of ammoniacal fumes on plants—why fish afford rich manure.

2. *Potash.*

Why called the Vegetable Alkali—is it confined to the vegetable kingdom—why called potash—potash of commerce impure—purified by freeing it of carbonic acid by means of quicklime (*Aikin's Dic.* 2, 240.) rationale.

Why it must be kept in close vessels.

Properties—effects on the skin—used as an escharotic (*Aikin's Dic* 2, 243)—attraction for water—used to dry the gases.

Decomposition—the first alkali that was decomposed—how effected—result—by whom obtained.

Potassium. Gay Lussac and Thenard's method of making it by passing melted potash over slips of iron heated to whiteness in a gun barrel (*Henry* 1, 367 *Aikin's Dic. Appendix* 54) rationale—properties—specific gravity—combustibility—action on water—action on the metallic oxids—all its effects owing to its powerful affinity for oxygen (*Henry* 1, 182.)

3. *Soda.*

Method of preparing pure Soda the same as for potash—properties much the same—points of difference.

Sodium—metallic—properties like those of potassuim.

4. *Soap.*

Principle on which it acts as a cleanser—a compound of oil and caustic alkali, but contains the latter in excess—why preferable to alkali alone. Quality of soap proportioned to that of the materials—of what are the finest varieties made?—castile soap used in medicine—why speckled—soft soap made with potash—hard soap with soda.

When soap is made from wood ashes necessary to add quicklime—why—salt added to soft soap to make it hard—rationale.

DIV. IV.—OF THE EARTHS.

1. Barytes, 2. Strontites, 3. Lime, 4. Magnesia,	Alkaline Earths.
5. Silex, 6. Alumine, 7. Zircon, 8. Glucine, 9. Ittria,	Earths Proper.

Why the first four are called alkaline earths—are the earths met with pure in nature—appearance when pure—insolubility—this property essential to the purposes they serve—alkaline earths slightly soluble—the others scarcely at all—infusibility. DECOMPOSITION. Alkaline earths all been distinctly analysed and shewn to be metallic oxids—first amalgamated with quicksilver in the Galvanic circuit—quicksilver distilled off—indications respecting the composition of the other earths similar but not equally decisive (*Murray* 1, 336)—why uninflammable. already saturated with Oxygen

1. *Barytes.*

Name—not found pure in nature—preparations of B. made for tests of sulphuric acid—in all its forms except the sulphate, a violent poison.

2. *Strontites.*

Properties similar to those of Barytes—different colours imparted to flame—not poisonous.

3. *Lime.*

Found very extensively in nature combined with acids, particularly the carbonic and sulphuric.

How formed from the carbonate—either from marble, oyster shells, or limestone—most of the lime of commerce from the last—mode of burning (*Aikin's Dic.* 2, 47. *Black* 2. 182.)

PROPERTIES. Action of *water*—whence the heat in the slaking of lime—why it is in the state of a *dry* powder after slaking—water solidified equals ¼ the weight of the lime—more solid than in the state of ice—Hydrate defined—air slacking—why the causticity is impaired—vessels set on fire by admitting water among casks of lime—waggons set on fire.—*Caustic* but less so than potash and soda—used by tanners—accelerates the dissolution of animal remains.—*Alkaline*—hence use in soap-making.—*Infusible* by itself, yet promotes the fusion of other earths—hence used in separating metals from their ores—rationale. *Sparingly soluble* in water—preparation of lime water—medicinal uses of lime water.

MORTAR—Roman mortar—importance of good mortar—qualities of good mortar (*Black* 2, 194)—kind of sand—proportions—use of beating—should be made and kept under cover some time before using—why mortar becomes hard after it is applied—use of lime in *Agriculture*—on what kind of lands most beneficial.

tenacity plasticity & turning hard

4. *Magnesia.*

alba & Calcined

In what states found—two kinds of M. sold at the apothecaries—difference between Magnesia Alba and calcined Mag.—infusibility—has it ever been fused? Use in medicine as an antacid.

yes

5. *Silex.*

rock, flint, sand

Name—extensively found in nature—in what substances—how to prepare pure silex or silica—its appearance—insolubility—infusible—indestructible—solvents—unites with the fixed alkalies and forms glass.

GLASS—discovery according to Pliny (*Rambler No.* 9)—was it manufactured among the Romans?—two principal ingredients—in what state is the silex—diversity of materials—for the finest flint glass—metallic oxids—use of manganese—different colours at different degrees of heat—removes the colours imparted by oxids of iron—red lead—imparts softness—proportion of silex and alkali.—Manufacture of glass vessels—manual dexterity—mode of forming a tumbler—a bottle—annealing—Bologna phial—Prince Rupert's drops (*Aikin's Dic.* 1, 495) causes of the inequality of glass—different kinds of glass—composition of *green glass*—cause of the colour—*crown glass*—composition—mode of making window glass—two methods—composition of white *flint glass*—contains metallic oxids, especially of lead—soft—grinding of glass—*plate glass* for mirrors—cast on a table—afterwards polished.

with Emeral powder

6. *Alumine.*

Pure clay—common clay contains a mixture of silex—how formed from alum—plasticity—a good soil depends on a due mixture of silex and alumine—evils when silex is in excess—evils when alumine is in excess—pipe clay—porcelain clay—composition of each—others—alumine found pure in the sapphire.

Most rocks and mineral substances made up of silex and alumine—rocks when called siliceous—when aluminous—porcelain clay formed by the decomposition of granite rocks—in what parts of the Unit[illegible] may we expect to find it—

on account of fusing with the alkalies

alumine imbibes water—parts with it slowly by heat and contracts—hence its use in Wedgwood's Pyrometer—very infusible—impresses this character on aluminous earths and clays—hence bricks and crucibles capable of enduring a high heat.

BRICK MAKING AND POTTERY. ancient arts—imperfect and rude at first—best earth for bricks—advantages of slow drying—cause of the red colour—of the partial vitrification.

General method of fashioning potter's vessels—baking (*Aikin's Dic.* 2, 245)—glazing—of what composed—manufacture of porcelain—introduced into Europe from China—perfection of the French porcelain—Clay selected with great care—must burn white—suspended in water—kneaded up—turned on the wheel—baked—now in the state of *biscuit*—figures applied—glazed by powdered feldspar—finest figures painted by hand (*Black* 2, 330).

Colours imparted by metallic oxids—blue by what—green—violet—purple.

7. *Zirçon.*
8. *Glucine.*
9. *Ittria.*

3 volumes of [illegible] [illegible] remaining [illegible]

DIV. V.—NATURAL HISTORY OF THE EARTHS,

Including Mineralogy and Geology.—V. Appendix.

DIV. VI.—ON ACIDS.

PROPERTIES.

1. Taste.
2. Effects on vegetable colours.
3. Effects on alkalies. neutralize the A: vice versa
4. What class of bodies do they form with alkalies, earths, and metallic oxides?
5. Attraction for water.

Must a body exhibit *all* these properties to be classed amongst the acids? *(Thomson* 2, 62*)*—Great use in decomposing bodies and promoting chemical researches—opinion of the old Chemists respecting the cause of their solvent power *(Aikin* 1, 10*)* result when a combustible body is burnt in oxygen—do any substances exhibit acid properties that do not contain oxygen?—composition of the acids—bases simple and double—latter belong chiefly to the animal and vegetable kingdoms.

Nomenclature of the acids. Who formed it? principles—(1) with regard to *simples* long known—ditto newly discovered (2) *compounds*—additions to the name of the base of *ic* or *ous* *(Henry* , 208. *Lavoisier* 92*)* —method adopted in treating of the acids, viz.

1. The *base* of the acid.
2. The base united with *oxygen* forming the acid.
3. Combinations of the acids with the earths and alkalies forming salts.
4. Combinations of the base with other *solids*.
5. Combinations of the base with *hydrogen*. e. g. sulphur, sulphuric and sulphurous acids, sulphates and sulphites, sulphurets and sulphuretted hydrogen.

I. OF SULPHUR AND ITS COMBINATIONS.

1. *Sulphur*.

Mostly from the mineral kingdom *(Aikin* 2 352*)*—In beds—Sicily—salt and gypsum—*volcanic* regions—Solfatara—a *deposit* around springs—in the state of *pyrites*.

Properties. Effects of heat—fusion and sublimation—flowers of sulphur—combustion in oxygen—product.

when the combustible is simple or double

2. *Sulphuric Acid.*

Why called oil of vitriol (*Parke's Essays* 2, 378)—composition—how manufactured—specific gravity—attraction for water—uses.

3. *Sulphurous Acid.*

Formed by the slow combustion of sulphur—by sulphuric acid and a metal—rationale—suffocating fumes—why collected over mercury—action on colours—use in bleaching (*Parke's Essays* 4, 154.)

4. *Sulphates.*

Import of the term salt—number of the salts (*Thomson* 2, 305)—nomenclature—*ic* changed into *ate* and *ous* into *ite*. Terms defined—neutral, sub and super, efflorescence, deliquescence, watery fusion, water of crystallization—effect of salts on the boiling points of fluids—CRYSTALLIZATION—an extensive process in nature—variety and regularity of crystals—rules for conducting the process—proportions in which different quantities of an acid combine with a given base—illustrated by *sub* salts and neutral salts.

SULPHATE OF SODA. Common name—how manufactured—taste—change by exposure to the air—by heat—sudden crystallization from a concentrated solution—rationale (*Annals of Philosophy*, 1.)

SULPHATE OF MAGNESIA. Common name—abundant in certain springs, particularly at Epsom—what property does it impart to spring waters?—artificial preparation from strong sulphuric acid and pure magnesia—phenomena attending their union—taste of this salt—medicinal properties.

SULPHATE OF LIME }
SULPHATE OF ALUMINE } referred to Mineralogy.

5. *Sulphites*—their composition.

6. *Sulphurets.*

Composition—native metallic sulphurets—called pyrites—mistaken for gold—artificial sulphurets called *livers*—why?—sulphuret of iron prepared by exposing equal parts of sulphur and iron filings to a glowing heat—must be kept in a close bottle—why?—sulphurets of the alkalies.

SULPHURETTED HYDROGEN. Composition—how formed—rationale—odour—liquid sulphuretted H. how prepared—precipitates metallic oxides—kind of metal ascertained by the colour of the precipitate—effect on vetetable blues—is it an acid?—natural sources—mineral waters—decayed animal remains. (*Henry* 1, 260—*Murray's System*, 2, 279.)

Attract Carbonic acid

II. OF CARBON AND ITS COMBINATIONS.

Base of all substances.

1. *Carbon.*

Term explained—base of all animal and vegetable substances—impurities of charcoal—how purified—formed in melted lead—in sand—how manufactured in the large way—different kinds.

PROPERTIES. Colour—imbibes gases—infusibility—conducting power—combustibility—indestructibility—charred stakes of the Thames—charring of casks and posts—how foul water may be purified—rancid oil and butter—spoiled meat—teeth powder—effect on ardent spirits by filtering through charcoal—lamp black, how prepared—ivory black—(*Aikin* 1, 161)—combustion of charcoal in oxygen—product—proofs that the diamond is pure charcoal (1.) when burnt in oxygen—it is converted into carbonic acid, the weight of which is equal to both the diamond and the oxygen employed (2)—iron converted into steel by being heated in contact with the diamond. (*Murray* 1. *Aikin* 1, 231)

2. *Carbonic Acid.*

Proportion of the ingredients—first gas known distinct from common air, discovered by Dr. Black, 1756—effect on the caustic alkalies—methods of obtaining it:

1. By psssing common air through red hot charcoal.
2. By pouring dilute muriatic acid on carbonate of lime.
3. By heating chalk or limestone powder in an iron tube.

Rationale of each method. Test for carbonic acid.

PROPERTIES. Sp. gravity—effect on burning bodies—on respiration—suffocation by exposure to the fumes of burning charcoal—in wells—how to detect it in wells—accidents from descending into such wells—Grotto del cane—choke damp—recovery of suspended animation—(*Gorham* 1, 386)—absorbable by water—how the quantity absorbed may be increased—☞ Water will absorb the same quantity of compressed gas as of gas under ordinary pressure—(*Henry* 1, 219)—affinity for water slight and easily overcome—native carbonated waters—sparkle—artificial carbonated waters—(soda waters)—how manufactured for sale—prepared in the small way—medicinal virtues—acid properties of this substance feeble—affinities weak—overcome by all the other acids.

SOURCES. (1) Combustion. What becomes of the great quantities thus thrown into the atmosphere—effect on vegetation.

(2) Fermentation. Sparkling of beer, cider, and other fermented liquors—great quantities produced in brewer's vats—bottling of cider.

(2) Respiration. Effect produced by blowing through lime water—changes on a confined portion of air by respiration—on the blood. (*Thomson* 4, 470. *Chemical Conversations*, 2, 230. *Murray's System*, 4, 465.)

3. *Carbo ic Oxide.*

Import of the term oxide as applied to a gaseous body—carbonic ox. contains half as much oxygen as carbonic acid—hence may be obtained by abstracting from carbonic acid half its oxygen. This done by heating together iron filings and chalk—rationale.

Properties. Combustible—blue flame—effect on respiration—product of the combustion—seen in a common fire and blacksmith's forge.

4. *Carbonates.*

Distinction between the perfect carbonates and sub-carbonates.

Sub-Carbonate of Ammonia. Other names—manufactured by the distillation of animal substances, such as horns, hoofs, &c. rationale—does it exist in animal substances ready formed, or is it produced during the distillation—rationale. Formed by direct union of its gaseous elements—appearance when thus formed—smelling bottles—spirits of hartshorn—uses in medicine, (*Aikin* 1, 258. *Murray's System* 2, 237. *Gorham* 1, 389.)

Sub-Carbonate of Potash. Chiefly of vegetable origin—how obtained from ashes, (*Aikin* 1, 258. *Thomson* 1, 265.) in what countries manufactured—pearl-ash how different from pot-ash—formation of the *perfect carbonate* by mixing it with Carb. Ammonia in solution and distilling—rationale, (*Murray* [illegible] *Aikin* 1, 260.) Medicinal applications under the names of salt of tartar and salt of wormwood—used in calculus, &c.—in making bread—rationale—in making soap and glass. Economy of wood ashes recommended—how they may most advantageously be employed as a manure.

Sub-Carbonate of Soda. Nitre of the Scriptures Nation lakes of Egypt—obtained from sea weed—kelp and barilla—a staple commodity of the Scottish Isles (*Encyclopædia Arts* "*Kelp*" and "*Barilla*") largely used in the manufacture of the finest white soap and glass—for soda water—

soda powders of perfect carbonate of soda and tartaric acid, rationale.

Carbonate of Lime.—A neutral salt—natural formations of it—referred to Mineralogy.

Sub-Carbonate of Magnesia. Light and porous—alkaline properties slight—calcined by heat · how calcined magnesia differs from the common magnesia alba—why preferred for delicate stomachs.

☞ These carbonated alkalies are all used as *antacids*, to correct sourness of the stomach, heart-burn, &c. Also employed as remedies against calculous disorders. (*Brande's Quarterly Journal, Nos.* 11 *and* 12)

5. *Carburet of Iron.*

Plumbago and black lead—composition—how distinguished—found of the best quality at Barrow Dale, Eng. Difficulty of finding it suitable for pencils—locality in this state—uses for pencils. crucibles, coating for stoves, paint, &c.

6. *Carburetted Hydrogen.*

Extensive combinations of carbon and hydrogen, beginning with the bodies that contain the greatest proportion of carbon.

(1) Anthracite or incombustible coal- of mineral origin—hard coal—will it burn in a common fire? does it burn with flame?—uses for furnace heats—Susquehanna and Rhode Island coal.

(2) Combustible coal. Contains bituminous matter—coke—vegetable origin—Richmond coal—North-Carolina coal—New-Castle and Liverpool coal—value to a country—accidental firing of coal mines—rules for distinguishing coal.

(3) Asphalt—concretes on the surface of waters—Dead sea—lake in Trinidad (*Cleaveland* 394)—used by eastern nations in embalming, and as an ingredient in mortar (*Jameson* 2, 364)—*Mineral pitch or petroleum*—swims on the surface of certain springs—abundant in Pennsylvania and Ohio called Seneca oil—used in rheumatic affections.

Vegetable substances made up chiefly of carbon and hydrogen with oxygen (carbon and the elements of water.) Hence vegetable products as gums, resins, oils, &c. constituted of the same elements in different proportions. Proportion of carbon constantly diminishing and that of hydrogen increasing, through a series of bodies from anthracite to ether—hence carburetted hydrogen obtained by exposing almost any of these substances to heat. Mode of obtaining it for experiment—rationale—carbonic acid how removed—how obtained from stagnant marshes (*Aikin* 1, 250. *Henry* 1, 236. *Gorham* 1, 391.)

Properties. Flame—product of the combustion, carbonic acid and water—rationale—rapid combustion when mixed with air—explosion when fired with twice its bulk of oxygen—effects on respiration—hazardous attempt of Davy to breathe it (*Davy's Researches*, *Gorham* 1, 396.)

Heavy carburetted hydrogen (*Quarterly Journal* 8. 337)—why called olefient gas—made from sulphuric acid and alcohol ☞ Rationale—carbonic acid and sulphurous acid formed along with the olefient gas but are absorbed by the water—pure flame.

Carburetted hydrogen extricated in coal mines—explosions—dreadful accident at the Felling colliery (*Annals of Philosophy*) attempts to prevent explosion—steel-mills—Safety Lamp—principle—nature of flame (*Gorham* 1, 504)—impossibility of communicating an explosion through small apertures—rationale (*Gorham* 1. 406) Gas Lights. How made—materials (*Quarterly Journal* 7, 312, & 8, 120) various products of the distillation of coal [gas, tar, ammonia and coke]—quantity of light distributed daily by the London company equal to half a million wax candles—comparative expense—superior convenience of the gas (*Gorham* 1, 409) Phenomena of a common fire.

III. Of Phosphorus and its Combinations.

1. *Phosphorus.*

Former celebrity and distinction—from what substance at first obtained (*Thomson* 1, 222) how manufactured from bones ☞ These are phosphate of lime—pulverised and heated with sulphuric acid—filtered—what passes the filter? What remains behind? The liquor containing phosphoric acid is evaporated—the solid residuum mixed with charcoal powder and exposed to a violent heat in a furnace—what takes place?

Properties. Colour—consistence—melting point—at what temperature does it take fire? Colour of the flame—why kept under water—combustion in oxygen—product—luminous appearance when exposed to air—why? Characters inscribed on a wall in a dark room—combustion under water—phosphoric matches—how prepared—liquid phosphorus how formed—glow-worm or fire-fly—phosphorus dissolved in ether—effects when taken into the stomach (*Orfila on poisons* 174.)

2. *Phosphoric Acid.*

Appearance like glass—extremely sour—decomposed by the Voltaic apparatus—rationale (*Gorham* 1, 421.)

3. *Phosphates.*

Class numerous, but phos. lime most important, why? Alkaline phosphates much used in medicine.

4. *Phosphurets.*

Formed by uniting solid phos. with inflammables and alkalies—phosphuret of sulphur extremely inflammable—phos't lime decomposes water at the common temperature (*Henry* 1, 321.)

5. *Phosphuretted Hydrogen.*

Procured by boiling bits of phosphorus in a solution of caustic potash—rationale—(*Henry* 1, 323. *Gorham* 1, 426) —also by adding bits of phosphorus to the usual mixture for hydrogen appearance when it comes in contact with the air —why? (*Gorham* 1, 428)—also when a bubble of the gas rises into a jar containing oxygen—extreme combustibility—why?—(*Gorham* 1, 429)—products of the combustion—ignes fatui.

IV. OF NITRIC ACID AND ITS COMBINATIONS.

Acids of which the base is nitrogen, viz:

Nitric acid,	Nitrous acid,
Nitric oxide,	Nitrous oxide.

Aqua fortis

1. *Nitric Acid.*

Name in the shops—composition—how proved by Cavendish—(*Henry* 1, 270. *Aikin* 2, 146)—proved by analysis—proportion of the constituents. ~~70 Ox. 30 N.~~ 2 N. 5 Ox

PROPERTIES. Common properties of an acid in a high degree—effect on the colour of the skin—on combustibles—on metals—manufactured from nitre and sulphuric acid—rationale.

USES. In minting—in lithography—in copper engraving as a chemical agent.

2. *Nitric Oxide.* 2 N. 2 O.

How it differs from nitric acid in composition—how formed from nitric acid and copper—rationale.

PROPERTIES. No acid properties—effect on respiration—on combustion—colour when mixed with oxygen—used as an eudiometrical substance—mode of its operation (*Henry* 1, 274.)

3. *Nitrous Acid.*

Formation—colour—composition—powerful in dissolving metals.

4. *Nitrous Oxide or Exhilirating Gas.*

Composition—preparation—rationale—action on combustibles—on animals when inhaled. History of its properties as developed by Sir Humphrey Davy. *(Davy's Researches, Murray 1, Gorham 1, 321.)*

Doctrine of DEFINITE PROPORTIONS illustrated by the foregoing combinations of oxygen and nitrogen.

☞ While the base remains fixed, all the higher proportions of oxygen in the several compounds are simple multiples of the lower. Thus,

	(Nitrogen.)	(Oxygen.)
Nitrous Oxide is comoposed of	2 measures	1
Nitric Oxide or Nitrous Gas	2	2
Nitrous Acid	2	4
Nitric Acid	2	5

(Chemical Catechism 45. *Gorham* 1, 49. *Thomson* 3, 22. *Henry* 1, 355. *Murray* 1.)

No intermediate proportions—do bodies combine in any other than *definite* proportions? Doctrine further illustrated by the composition of other bodies consisting of different proportions of the same elements, as acids, salts, & metallic oxides.

Cause of this definiteness explained by

THE ATOMIC THEORY.

Structure of bodies out of atoms maintained by Epicurus and Newton—revived by Dr. Higgins and chiefly illustrated and extended by Dalton—his idea of atoms, *that the atoms of the same body are of the same size and figure; but that those of different bodies vary in size and figure.* In the foregoing combinations,

1 atom of Nitrogen with	1 of Oxygen	forms	Nitrous Oxide.
	2	do.	Nitric Oxide.
	4	do.	Nitrous Acid.
	5	do.	Nitric Acid.

☞ When two elements combine only in one proportion forming only one compound, it is *assumed* that the combination is *binary*. When the same elements form several compounds, the first or lowest is assumed to be binary. Thus 1 atom of hydrogen with one of oxygen, forms *water*—why then does the oxygen amount to 7 times as much as the hydrogen in *weight?* Ans. Its *atoms* are 7 times heavier. Hydrogen assumed as the standard, being considered as *unity*, and the atoms of all other elements compared with it—hence the *relative* weights of atoms ascertained.

Practical utility of the Atomic Theory.

Composition of a substance (its elements being known) deduced from calculation--experimental analysis thus confirmed--Wollaston's scale of chemical equivalents (*Gorham* 1, 54.)

5. *Nitrates.*

Solubility in water—deflagration. Saltpetre

Nitrate of Potash. Common names—found native—caves of Kentucky (*Cleaveland* 108,) how formed in caves—nitrous soil of Spain (*Aikin* 2, 156.) India—manufacture—mixture of wood ashes—rationale—manufacture put into the hands of the French chemists during the revolution—result—artificial nitre beds of France—how formed (*Aikin* 1, 159.)

Properties. Form of the crystals—fusion—action on burning coals when fused—deflagration.

Uses. In the manufacture of sulphuric acid—in preserving meat—for oxygen gas—for gunpowder.

Gunpowder.

History—Roger Bacon—Chinese. First used in war at the battle of Cressy, 1346. Manufactures—ingredients—proportion of each—preparation—how mixed, grained, glazed, dried—defects, to what owing—trial of the quality—inferiority of American to English powder—cause. Successive explosion of the grains—effect of pressure—cause of the report—gases produced—production of heat—how accounted for (*Murray's System* 2, 589.)

Pulvis Fulminans. Ingredients—how made—cause of the explosion. 3 N 2 Pearl ash . Sulphur

V. Of muriatic acid and its combinations.

1. *Muriatic Acid.*

Why so called—how obtained from salt—great condensation in water—white clouds with ammonia. *Nitro Muriatic Acid*—aqua regia—celebrated property of this substance.

2. *Muriates.*

Muriate of Ammonia. Originally brought from Lybia—how manufactured in Egypt (*Parke's Essays* 4, 346,) from the distillation of substances containing animal remains.

Uses. In dying &c.

Muriate of Soda. (Salt.) Focus of saltness, derived from this substance—found in three situations.

(1) Waters of the Ocean.

(2) Salt springs—of Cheshire, Eng. (*Aikin* 2, 118,) of New-York—of Kentucky—salt licks (*Cleaveland* 115.)

(3) Salt mines—of Poland *(Encyclopœdia Art. 'Wielicza')* their antiquity—known 600 years—1000 feet deep—curious figures wrought out of the solid rocks—*(Black.* 2, 112.*)*—Salt mountains of Cordova in Spain—500 feet high—*(Bakewell's Geology)* salt mines of Peru—*(Jameson* 2, 320. *Humboldt's Personal Narrative* 2, 268.*)*

Rules for detecting the presence of salt.

Manufacture of salt.

1. From sea water—where most strongly impregnated—mode of manufacturing by the heat of the sun—by boiling—which method produces the best salt—Scotch Sunday salt—*(Black* 2, 117*)*—impurities in sea water.

2. Salt springs—very strong—from $\frac{1}{4}$ to $\frac{1}{2}$ lb. per gallon—(*Cleaveland* 115)—manufactured by boiling.

3. Rock salt—obtained by mining, and afterwards dissolved and crystalized to separate impurities.

Properties. On burning coals—equally soluble in hot and cold water—crystallizes in cubes.

VI. Oxy muriatic acid or chlorine.

Formation from muriatic acid and manganese—rationale—colour—hence its name—suffocating fumes.

Combinations. (1.) With olifient gas. (2.) With hydrogen—forms muriatic acid—rationale—(3.) With combustibles—phosphorus and metals inflamed spontaneously—why? effect on vegetable colours—bleaching—mode of disinfecting sick rooms—easy mode of producing the gas in a tea cup.

☞ Explain all the preceding facts on the supposition that chlorine is a *simple body*.

1. How is chlorine formed by the mixture of muriatic acid and manganese?

2. How does the union of chlorine and hydrogen produce muriatic acid?

3. Why does it cause phosphorus and the metals to inflame spontaneously?

2. *Chlorate or Oxy Muriate of Potash.*

Formation—rationale. ☞ 2 salts formed, viz. muriate and chlorate—that part of the acid which goes to form the muriate is withdrawn, and leaves all the oxygen combined with the remainder—hence this salt is a hyper—oxymuriate—*(Henry* 1, 311.*)*

Violent detonation with inflammables—*(Murray* 1. *Henry* 1, 311, *Chemical Catechism)*—why trituration or percussion causes an explosion.

VII. OF IODINE AND ITS COMBINATIONS.

1. *Iodine.*

Discovery—from what substance obtained—method of obtaining it by lixiviation and sulphuric acid—rationale.

Colour—name—scales—volatility—relation to the galvanic poles—a supporter of combustion *(Gorham* 1, 258*)* test.

2. *Hydriodic Acid.*

Composition—hydrogen united with iodine either at a high temperature or in the nascent state—strongly acid *(Murray's Syst.* 2, 501.*)*

3. *Oxiodic Acid.*

Composition.

Analogy between Iodine and Chlorine—effect of its discovery on the theories respecting the latter *(Murray* 1.*)*

VIII. FLUORIC ACID AND ITS COMBINATIONS.

Obtained from Fluor spar (Fluate of Lime) by sulphuric acid—rationale—a liquid when pure—corrosive properties *(Murray* 1. *Gorham* 1. 265.*)* Action on silex—etching of glass *(Thomson* 1, 180.*)*

2. *Fluate of Lime*—referred to Mineralogy.

IX. BORACIC ACID.

Obtained from borax which is *borate of soda*. This salt found in the lakes of Thibet. Renders metallic oxides more fusible—used in soldering.

DIV. VII.—METALS.

Eagerness of mankind for these substances—criterion of civilization estimated by the knowledge of them and the degree of skill in working them—importance to alchymists and chemists.

1. *Natural History of the Metals.*

(Silliman's Notes to Henry 2, 389.*)*

Metals usually occur in nature under disguised forms—when called native—what metals most frequently occur native? usually found combined

1. With oxygen, forming oxides.
2. With acids, forming salts.
3. With sulphur and carbon, forming sulphurets and carburets.

Ores make up but a small part of the globe—veins—are these inclined or horizontal?—do they consist entirely of ore? gauge of a metal—most abundant in rugged mountainous countries.

Credulity evinced by the vulgar on the subject of metals—divining rods—real indications of a mine—boring.

MINING Great labour at the beginning—how access is gained to the ore—mode of removing the ore—use of the steam engine.

METALLURGY. "The art of extracting metals from their ores." Sorting, stamping, washing, reducing and refining—each defined.

2. *Physical Properties.*

LUSTRE. The brilliancy of metals exhibited by the *interior*—that of other bodies *superficial*—hence useful for purposes of ornament and for mirrors.

OPACITY. Peculiar to the metals. Is gold leaf an exception.

DENSITY. Greatest in the metals—weight of a cubic foot of cork contrasted with a cubic foot of gold and platina.

TENACITY. How estimated—which metal has the greatest?

DUCTILITY. "The property of being drawn out into wire." Great difference among the metals in this particular—wire-drawing.

MALLEABILITY. "The power of being extended into thin plates"—not possessed by all the metals.

CONDUCTING OF CALORIC AND ELECTRICITY.

FUSIBILITY. Great difference in this respect—extremes, quicksilver and platina.

3. *Chemical Properties.*

OXIDATION—effect of moisture—nature of rust—distinguished from *tarnish*—agency of heat in promoting oxidation—calcination—how accounted for on the Phlogistic Theory—on Lavoisier's Theory—*different* metals combine with different portions of oxygen e. g. gold and iron—the *same* metal also combines with several portions of oxygen constituting several distinct oxides e. g. *lead*—colours---are the elements of these oxides united in *definite* proportions? (*Murray* 2, 16. *Gorham* 1, 56)—modes of naming the several oxides of a metal.

Reduction—how performed. Analogy between oxidation and combustion—metals *combustible.*

ACTION OF ACIDS. How the acids act in dissolving the metals—acid decomposed—sometimes the acid enables the metal to decompose water—what substance is then given out?—formation of *metallic salts*—composition—what acids act with the greatest energy on the metals?

Alloys. How formed—are the ingredients in mechanical mixture, or in chemical combination?

Enumerate the metals in their order (*Murray*)

1. Gold.	10. Iron.	19. Manganese.
2. Silver.	11. Lead.	20. Molibdena.
3. Platina.	12. Tin.	21. Tungsten.
4. Iridium.	13. Zinc.	22. Chrome.
5. Osmium.	14. Bismuth.	23. Tellurium.
6. Rhodium.	15. Antimony.	24. Titanium.
7. Palladium.	16. Arsenic.	25. Uranium.
8. Quicksilver.	17. Cobalt.	26. Tantalium.
9. Copper.	18. Nickel.	27. Cerium.
		28 Silenium

Method pursued in treating of the metals, viz.

Natural History,
Physical Characters,
Chemical Characters,
Applications to the arts.

OF GOLD.

Sol et rex metallorum of the alchymists—use and abundance among the ancients—(1 *Kings*, 10. 14. *Parke's Essays* 5, 248)—regard paid to it by the alchymists—why?

Natural History. Found native—alloyed with silver, copper, iron, and palladium—dispersed through hard rocks or in grains—extent to which it is diffused—small proportion of gold found among the ores and sands—how many ounces to 5,000 lbs. of the ore of Chili—how many grains to the ton of, sand in Africa—localities—Hungary and Spain—eastern and western coasts of Africa—California, (Sonora,) Mexico and Brazil, Ancient Pactolus, Rhine and Danube. Is the gold of rivers always brought down from the mountains?—separation of gold from its ores—use of mercury. (*Aikin* 1, 521.)

Physical Characters. Colour—hardness—ductility—*malleability*—gold-beating how conducted—into how many square inches may a grain of gold be extended?—thinness of gold on gold lace.

Chemical Characters. Acted on but by few chemical agents—why it does not rust—can it be oxidized by heat?—action of acids—two oxides—colours—aqua regia—*muriate* formed—rationale—action of muriate of tin on the solution—

purple precipitate of cassius—action of *ammonia*—fulminating gold—rationale—*(Murray)*—action of *combustibles*, as hydrogen, phosphorus, &c.—action of *ether* on the solution—aurum potabile.

Applications to the Arts. Gilding by means of the ethereal solution—*(Chemical Amusement*, 96. *Parkes*, 551*)*—standard gold coin—purity estimated by carats—jewellers' gold—how does copper affect the colour of gold—how does silver?—pure gold useful for chemical vessels.

OF SILVER.

Known to the ancients—abundant in nature—greatly valued in the arts.

Natural History. Frequently found native—sometimes combined with arsenic, antimony or sulphur—contained in lead ores—how to distinguish native silver from lead—localities—mines of Norway—of Saxony—of America—annual product of the Mexican and South American mines—product for three centuries—*(Jameson* 3, 91. *Rees's Cyclopædia)*—*reduction*—volatile matters expelled by roasting—use of mercury—great labour to remove all the foreign substances—1,600 ounces of ore yield only 3 or 4 ounces of pure silver—*(Cleaveland*, 442.*)*

Physical Characters. Whiteness—called luna—malleability and ductility compared with gold.

Chemical Characters. Fusion—appearance when in the melted plate—combustion—colour of the flame—not subject to spontaneous oxidation—tarnish—action of nitric acid—nitrate of silver—appearance when crystalized—action on inflammables—explosion with oxygen—rationale—combination with ammonia—fulminating silver—rationale—very dangerous—another formed by the action of nitrate of silver on alcohol—experiments—action of mercury on the nitric solution—Arbor Dianæ—formation and rationale—action of light on nitrate of silver—durable ink, how applied—test for muriatic acid—why?—preparation of lunar caustic—antiputrescent properties—(*Black* 3 353)—precipitation of metallic silver on copper—rationale.

Applications to the Arts. Plating, how performed—sivering of dials and clocks—(*Black* 3, 357)—utensils and furniture of silver—silver coin.

OF PLATINA.

Chiefly obtained from South-America—in grains scattered in sandy districts—other valuable metals associated with it.

Colour—lustre--malleability and ductility—☞ Specific gravity.

Acted on by few agents—hence not liable to rust or tarnish --solvent—infusibility—has it ever been fused in a furnace? —hence difficulty of uniting the grains into a mass—general method of doing this.

Useful for chemical vessels—why?—porcelain coated with it—crucibles.

☞ Metals separated from the ores of Platina, Iridium, Osmium, Rhodium, and Palladium. (*Murray* 2, 56. *Henry* 2, 44.)

OF MERCURY OR QUICKSILVER.

Extensive examination made of it by the alchymists--their object--utility of these researches in bringing to light the properties of the substance.

NATURAL HISTORY. Met with in but few places; but is abundant in those places--Idria--Almaden--Guanca Velica—(*Cleave and* 447. *Jameson* 3, 39. *Aikin* 2. *Black* 2.)—antiquity of the mine at Almaden—Peruvian vein 50 yards in diameter—occurs (1) in globules (2) in a sulphuret called *cinnabar*—colour of this ore—how is the quicksilver obtained from these ores?—iron or lime employed in the distillation—why?—mode of transporting mercury.

PHYSICAL AND CHEMICAL CHARACTERS. A *melted* metal--how congealed--properties when congealed--at what temperature--boiling point--(*Henry and Parkes' Tables*)—repeated distillations performed by Boerhaave--result—effect of agitation—importance of mercurial preparation to the medical student.

OXIDES. *Black* oxide--formed by agitation—by triturating with fat--office of the fat—(*Murray's Materia Medica* 2, 292)—only 4 per cent. of oxygen—properties rendered more active—effect of pure quicksilver on the system. (*Aikin* 2, 75.) *Red* oxide, how formed—contains 7 per cent. of oxygen--how it may be separated. ☞ This is the substance from which Dr. Priestley discovered oxygen. Oxidation by means of nitric acid—formation of *red precipitate*—(*Aikin* 2, 78. *Murray's Materia Med.* 2, 240)--more corrosive than the *mercurius precipitatus per se.*—used as an escharotic—change produced on the red precipitate by triturating it with running mercury.

Action of *sulphuric acid*, and preparation of the super-sulphate and sub-sulphate—turpeth mineral.

Action of *muriatic acid*, and formation of CALOMEL and CORROSIVE SUBLIMATE. Does muriatic acid act on *metallic* quicksilver ?—metal first oxidized by the nitric or sulphuric acid—corros. sublimate prepared from sulphate of mercury and muriate of soda—rationale—excessively poisonous—(*Orfila on Poisons*, 19)—quantity for a dose—mode of detecting it in a supposed poisonous mixture.

Calomel, how prepared from the corros. muriate—how it differs from the latter—how they may be distinguished.

Mercury with *sulphur*—preparation of *Æthiops* and *Cinnibar*—(*Black* 3, 245)—vermillion.

Fulminating mercury, how formed—experiments.

Mercury in all its preparations poisonous, but made by a skilful application, extremely useful in the cure of diseases.

APPLICATIONS TO THE ARTS. Amalgams how formed—use of mercury in reducing gold and silver—amalgam with zinc—with tin—coating of mirrors—(*Black* 3.)

OF COPPER.

NATURAL HISTORY. Use of it by the ancients—colour of the ores—localities. Cyprus—Cornwal—l Anglesea—annual amount afforded by the English mines, 10,000 tons—(*Jameson* 3, 196,)—no large copper mine in the United States. Found native—also with sulphur and arsenic. *Reduction*—roasting and fusion—sulphur thus afforded for market—(*Black* 3. *Aikin* 1. *Chaptal* 362.) Rules for distinguishing copper ores—resemblance of copper pyrites to gold.

PHYSICAL PROPERTIES. Colour—malleability—ductility—a durable metal—hardness—does it strike fire with flint—use for powder casks, &c.

CHEMICAL PROPERTIES. Changes wrought on it by exposure to the atmosphere—degree of heat required for its fusion—contain a great portion of latent heat—(*Black* 3. *Aikin* 1, 333,)—combustion—colour when burning.

Sulphuric acid—sulphate of copper—blue vitriol—how manufactured in the large way—(*Chaptal* 363)—waters containing it in solution—effect on iron utensils.

Nitric acid—nitrate—action on combustibles—with phosphorus struck on an anvil—wrapt up with tin foil—paper wet in the nitric solution and set to dry by the fire—paper wet with alcohol dipt in this solution and inflamed—metallic copper revived—why ?

Muriatic acid—dissolves copper with difficulty—colour of the solution—*Acetous* acid or vinegar—verdigris—how manufactured—use—action oily matter on copper—brass candlesticks—ammonia—dissolves the oxide—colour—test for copper—food poisoned by the use of copper vessels—how detected—iron applied to a solution of copper—copper filings heated with sulphur—phenomena made an objection to Lavoisier's Theory of Combustion.—*(Black 3.)*

Applications to the Arts. Utensils of copper—alloys —coin—brass—bell-metal and bronze.

OF IRON.

Natural History. Abundant in nature—ores numerous.

Native Iron. Soft and malleable—remarkable circumstances attending it—how regarded by the natives—analogy to *meteoric stones.* Hints of stony bodies descending from the atmosphere furnished by the ancients—Weston meteor—phenomena attending it—*(Memoirs Cont. Academy, vol.* 1. *Rees's Cyclopœdia, Art.* "*Falling Stones.*" *Henry* 2, 401.*)*—size and velocity—fragments detached—composition—(silex and magnesia, iron and nickel)—theories respecting the origin of these meteors.

1. Thrown out of *volcanoes.* Objections—distance from any known volcano—size—direction.

2. From *volcanoes in the moon.* Objections—force requisite to throw so large a body 24,000 miles—effect of such a discharge on the moon itself—losses that planet would sustain by supplying meteors.

3. *Atmospheric Concretions.* Objections—how these materials were furnished—why they did not descend sooner—direction.

4. *Terrestrial Comets.* Analogy to solar comets—heat and light, how accounted for.

Iron Pyrites. Abundant—mistaken for gold—how distinguished—colour when arsenic is present—how to detect this —uses in the manufacture of sulphur and copperas.

Magnetic Iron. Mistake in supposing all ores of iron magnetic—degree of oxidation—load stone—iron sand—species useful for bar iron.

Specular Iron. Why so called—its appearance—colours—quality—localities.

Red Iron Ore. Colour—to what owing—stalactites—common in the U. States—afford a tough iron—used for anchors.

Argillaceous Iron. Mixed with clay—in nodules—eagle stone and bog iron—much used in England.

Manufacture of Britain—Sweden—Russia—U. States—North-Carolina.

Reduction. Roasting—placed in the furnace with lime and charcoal—fused—removal of the slag—rationale of the whole process—mode of casting—running into pigs—manufacture of bar iron—fusion of pig iron—hammering—rationale of the process.

Physical Properties. Tenacity compared with lead—fracture—ductility—malleability—increased by heat—welding (*Black* 3, 165) rationale.

Chemical Properties. *Oxidation*—change on exposure to the atmosphere—rust—how to preserve iron from rusting—effects of heat and formation of the black oxide—melting point—combustion—effect of acid and saline substances in corroding iron—*Acids*—all act on iron, strong acids with great energy—why apples blacken knives. Sulphate, formation, colour, and crystallization—effect of heat on this salt and formation of the red oxide or crocus martis.

[Medicinal preparations of Iron.]

Ochres. Used in painting—oxide of iron an extensive colouring drug in nature.

Sulphuret—Lemeng's Volcano—Carburet, Plumbago and Steel.

Properties of Steel. Hardness, polish, tenacity, brittleness, ☞ definition, "refined iron united with carbon"—carbon in a state similar to the diamond—how steel differs from cast iron—manufacture of steel—bar iron stratified with charcoal in a trough—heated in a furnace—blistered, German and cast steel—mode of making each—tempering of steel—degree of hardness how judged of (*Aikin* 1, 603. *Parke's Essays* 4, 500) Cutlery—state among savage nations—among ancient civilized nations (*Parke's Essays* 4.) Sheffield and Birmingham.

Applications to the Arts. Extremely numerous and important.

OF TIN.

Natural History. Mines few but abundant in ore—Cornwal and Banca—antiquity of the Cornwal mines—annual amount of ores raised from them—ores of tin mineralized by iron and sulphur. Reduction.

Physical and Chemical Properties. Colour—hardness—malleability—tin foil, how much thinner than gold leaf—cry of tin. *Oxydation*—tarnish—has water any action on it?

melting point—rapid oxidation and formation of the *grey* oxide—combustion—promoted by nitre—why ?—formation of the *white* oxide from the grey—putty, used as a polishing powder—enamel of watch faces. *Acids*—rapid action of nitric acid ☞ when the acid is diluted with water, the metal decomposes both and ammonia is formed—rationale. Muriate of tin—decomposes the solutions of gold and throws down the purple precipitate of Cassius—rationale.

Applications to the Arts. Alloys with copper—bronze, bell metal, cannon metal, ancient weapons translated " brass" —hardness of this alloy—manufacture of tin plate—utility for culinary vessels. Composition of *solder*. Pewter—composisition—lead apt to be in excess—then dangerous to keep acid liquors in (*Aikin* 2.)

OF LEAD.

Natural History. Found in veins frequently large and extensive—ores various, but the sulphuret or galena most abundant—how distinguished from pure lead. Mode of examining a specimen of lea[illegible]e with the blow pipe.

Physical and Chemical Properties. Softness, malleability—manufacture of sheet lead—granulation of lead and manufacture of shot. *Oxydation*—tarnish, melting point and formation of the grey oxide. Changes produced on this oxide by farther exposure to heat. Massicot and Red Lead or Minium how formed—litharge (*Aikin* 2, 19)—tendency of the oxides of lead to vitrify with silex, hence their use in glass-making and pottery. *Acids*—acetate of lead—white lead, composition and manufacture—action of lead on the human system—waters proceeding from lead mines—pipes and vessels of lead—diseases incident to those who work among the oxides of lead. Uses of lead in painting—remarks on the preparation of paints.

OF ZINC.

Natural History. Ores known to the ancients, but not the pure metal—two principal ores Calamine and Blend—manufacture of brass from the ores—reduction to the metallic state.

Physical and Chemical Properties. Fracture, malleability, increased by a moderate heat—fusion and formation of the *grey* oxide—combustion and formation of the *white* oxide called flowers of zinc, nihil album, and lana philosophica. *Acids*. Strong action.

[Medicinal applications of Zinc.]—Eye water

Alloys. Brass—composition and uses—Corinthian brass composed of gold, silver and tin—*(Encyclopædia)*—electrical amalgam, voltaic plates, pinchbec, prince's metal, tombac.

OF BISMUTH.

Not found extensively—fusibility—crystallization—alloy with lead and tin forming the *fusible metal*—white oxide of bismuth—preparation by nitric acid—medicinal uses—a celebrated cosmetic—sympathetic inks of nitrate of bismuth.

OF ANTIMONY.

Distinction between the common antimony of the shops and the regulus of antimony—appearance under the blow pipe—brittleness—imparts this character to other metals—its celebrity among the alchymists. *(Black* 3.*)*

[Medicinal preparations and applications.]

In the arts. Alloyed with lead and bismuth constitutes type metal—reason of adding the antimony and bismuth to the lead.

OF ARSENIC.

Ores, orpiment and realgar—how to detect an ore of arsenic—reduction of the ores—fate of the workmen—white oxide of arsenic—effects on the human system—*(Black* 3, 136. *Orfila on Poisons*, 45*)*—mode of detecting mineral poisons in criminal cases.

[Medicinal preparations of arsenic.]

OF COBALT.

Ores found in Saxony and Connecticut—combined with arsenic, zaffre and smalt—composition and use of the latter—use of cobalt in colouring glass and pottery—nitrate of cobalt a fine sympathetic ink. *(Aikin* 1, 579.*)*

OF MANGANESE.

Black oxide—abundant—violet colour, with borax infusion—use in glass-making and bleaching—cameleon mineral.

Chapel Hill

W Outlaw W. Evans & J Bryan Esq[illegible]
ne Evening at 3 Oclock